WebDietAID: An Interactive Web-Based Nutritional Counselor

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Abstract

WEBDIETAID *is a Web-based system aimed at assisting individuals affected by high serum cholesterol. The system tries to reproduce the types of intervention performed by a nutritional counselor. It is structured as a set of* advisors, *each of which handles a different side of the counseling process. The tasks of the advisors range from monitoring weight, to teaching about healthy nutrition, to assessing motivation and psychological obstacles to behavior change.* WEBDIETAID *is based on a development environment for Web-based applications that includes a dynamical Web server, a knowledge base management system, and an interface to a relational database. We describe the architecture of the system, and several of the implemented advisors. Finally, we discuss how the architecture could be generalized to other counseling domains.*

1 Introduction

A large number of Web-based systems have been developed in the health field, from education and counseling systems [1], to disease monitoring systems [2], to automated diagnostic and therapy planning tools [3]. In our opinion, however, few of these systems exploit the full potential of the Web in terms of interactivity and flexibility of presentation. Most systems are designed to provide static content to the user, with few attempts to take specific characteristics of the user into account. Moreover, the "structure" of the site, that is, the set of paths that the user can follow while navigating it, is usually limited in scope and constrained to a tree-like form. In other words, such sites are based on the traditional library model: one in which the user can only browse through a collection of static documents, with little help in deciding which path to follow in order to obtain the highest possible benefit from using the system.

In this paper we describe an architecture for the creation of Web-based applications, currently under development in the Medical Information Systems Unit of Boston University Medical Center. Our system uses sophisticated Web technology to reproduce, as closely as possible, the interaction that takes place between a patient and a clinician providing counseling on a specific health care problem. The medical domain we selected for the initial application is the reduction of serum cholesterol through changes in food consumption and other behavioral changes (physical activity, changes in food shopping decisions, etc.) This problem domain lends itself poorly to quantitative intervention techniques, and requires instead a range of well-coordinated interventions that focus on several different aspects of the patient's lifestyle. In Section 2 we describe the technology with which WEBDIETAID is built, while in Section 3 we discuss in detail the types of interventions that a nutritional counselor uses with patients, and how WEBDIETAID tries to reproduce the same interactions with its users. In Section 4, we discuss some plans for the future development of the system.

2 The software architecture

The LISPWEB development environment [4] is a platform that facilitates the rapid creation of sophisti-

1067—5027/00/$5.00

cated Web applications. The main component of LISPWEB is a programmable Web server, written in the Common Lisp programming language. LISPWEB allows the developer to define the system structure and interface using a high-level programming language, that includes a comprehensive library of HTML-generating functions; the server will then turn the definitions into Web pages in response to user interaction. With respect to the traditional solutions based on server-side CGI scripts or servlets, this approach provides greater speed (since the pages are generated by functions run by the server, and not by external programs), and makes the development of complex applications easier, thanks to the use of a high-level language and of a non-stateless transaction model.

In addition, LISPWEB includes an object-oriented knowledge base management system (KBMS). The KBMS can be used to represent declarative knowledge, by expressing it as a set of interrelated *classes* of objects and *instances* of such classes. Since objects are implemented using the Common Lisp Object System (CLOS), it is possible to define *methods* that operate on their instances and take advantage of the inheritance and specialization features typical of object-oriented systems. For example, the developer can define a general method to output an HTML representation of the instances of a class, and reuse it or specialize it for its subclasses.

The architecture of LISPWEB is completed by an interface with SQL databases that operates over TCP or ODBC connections. This interface allows the server to access the database directly (using functions that generate SQL code), or through the KBMS. Given a class, the system is able to create a database table that reflects its structure, to store instances of the class as records in the table, and to create instances holding the data retrieved from the table.

Overall, LISPWEB offers a very powerful development environment that combines high-level tools to represent and store information with very fine control over the generation of the Web pages and the HTTP connection. LISPWEB has been successfully used as the heart of distributed information systems in a number of medical informatics projects [3, 5].

3 Nutritional counseling on the Web

Lowering serum cholesterol can be achieved through a number of lifestyle modifications, whose basic elements are changing diet, reducing weight, and increasing exercise. Making meaningful adjustments to these behaviors can also involve changing other stressors, like work and family roles, plus recreational style, and finally the ability to make decisions or sense of self-efficacy (the belief that one can change his/her dietary behavior).

Since expert nutrition counseling for lowering serum cholesterol levels is a complex process, WEB-DIETAID is structured as a set of *advisors*. Each is responsible for interacting with the user on a specific issue (e.g., weight control, shopping habits) by dynamically generating a set of Web pages. The pages can be used to present information to the user (e.g., a description of the different types of milk – skim, low-fat, regular), to acquire information from the user (e.g., monitoring weight), or both.

Advisors compete with each other for the user's attention, according to priorities set by the system designer. Priorities can be fixed, or can be determined by rules that take into account the state of the system. In this way, the system can adapt itself to the situation at hand and to the specific policy chosen by the developer. In certain situations it will be desirable to activate two advisors in succession (for ecample, if one of them relies on data collected by the other). In this case, the priorities will initially be set so that the user is forced to activate the first advisor; at that point the priorities will be changed in order to disable the first advisor and enable the second one. In other situations, it could be preferable to leave a wide range of options available to the users. The users would thus be able to select the "path" to take according to their individual needs and inclinations, instead of being forced to follow a predefined script.

The system stores a *model* of each user in the database, and uses the information contained in it when generating the pages or determining priorities. Such information ranges from demographic data (age,

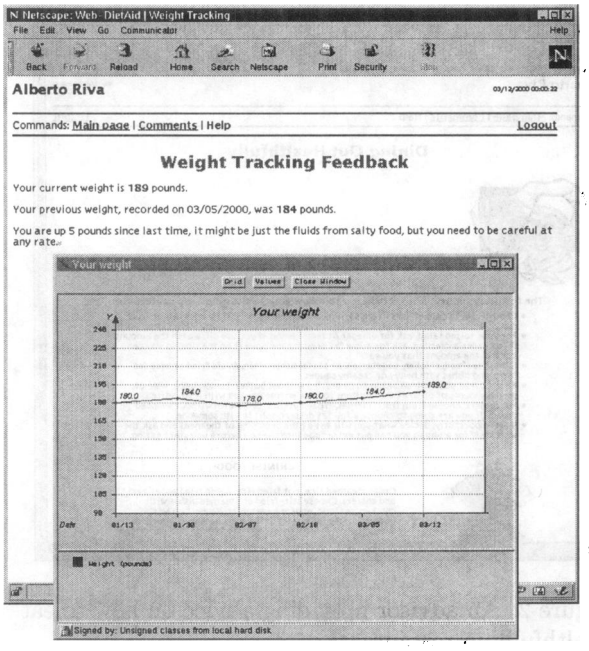

Figure 1: The output of the weight tracking advisor, including textual feedback and a graphical view of the weight monitoring data.

gender) to broad classifications of food and exercise habits (sedentary, active, very active), to information about the user's interaction style with the system obtained by analyzing clickstream data (e.g., by measuring how often and for how long a user visits a particular page). For example, if a user only spends a few seconds looking at a page containing a long table of nutritional values for different foods, the system might deduce that the user is easily bored by tables, and, the next time, present the same information in a narrative form.

In the following, we present some examples of common counseling tasks, and we describe existing of planned WEBDIETAID advisors that implement them.

3.1 Monitoring

Excess weight contributes to elevated serum cholesterol. One of the most important tasks of a nutrition counselor is therefore to monitor the patient's weight, to inform him or her about the consequences of excess weight, and to help obese individuals lose weight.

The first advisor we describe offers users the opportunity to have their weight monitored. This advisor asks the users to input their weight weekly, and provides short textual feedback on positive or negative changes, designed to motivate overweight individuals to lose weight. The data is recorded in the database, and users can see a graphic display of weight status trends over weeks or months, that underscores the motivational messages. Figure 1 shows a sample output of this part of the system.

Exercise also can lower cholesterol, and help reduce weight. People are routinely asked about their personal fitness program; if not pursuing one, they are educated about useful home-based activities. WEBDIETAID includes an advisor that assesses the user's physical activity level and provides advice on how to maintain a healthy lifestyle.

3.2 Diet Assessment

In clinical practice, a counseling session typically begins with assessing patients' usual dietary intakes. Patients' responses inform the clinician about which foods and intake habits are contributing to elevated serum cholesterol. The most harmful foods are those with high levels of saturated fat, such as whole-fat dairy products, and red meat. Lack of adequate fruit, vegetables, and fiber-rich foods, can be an issue as well.

The diet assessment advisor in WEBDIETAID presents an online questionnaire modeled after the MEDFICTS dietary assessment instrument [6]. The questionnaire asks current weekly food intake in groups like fruits, vegetables, and desserts. Since the questionnaire is long, the system allows the users to complete sections of their choice, postponing the other sections to successive sessions. The whole questionnaire is repeated periodically, and the answers are used to compute numerical scores. Users receive positive feedback if they have made progress in changing intake in specific areas like red meat, compared to previous queries. The system is sensitive to lapses and repeated failures, in which case it raises the pri-

ority of another advisor that queries patients about barriers to change, and provides suggestions to overcome these obstacles.

3.3 Education

Next, patients need to learn about dietary changes that are likely to be useful to lower their serum cholesterol. After clinicians make these recommendations, it is usual for the patient and clinician to discuss which dietary changes to make first. The discussion should balance the effectiveness of any change in diet with the patients' preferences in food.

To accomplish these same goals, WEBDIETAID uses a database containing nutrient information on over 6,000 food items [7]. WEBDIETAID's educational advisors can display several comprehensive food composition tables. The advisors can also display sample meals that meet nutritional guidelines. Users have the option to create their own daily menu from these meals, or choose a predefined one displayed by the advisors. Since food consumed in restaurants is a significant source of nutritional intake for Americans, a specialized advisor presents dietary guidelines and menu suggestions for many types of restaurants, including fast-food and ethnic restaurants (See Figure 2). Another advisor helps the user to create a printed shopping list and, while doing so, provides positive or negative feedback on the user's choices, suggesting replacements for unhealthy foods.

The system takes into account people's taste preferences. Some individuals may not consume a whole category of food. At the same time, specific foods, like oatmeal, are being identified as therapeutic for lowering cholesterol, and should be suggested by the advisors. For people who have low intakes of water-soluble cereal or fruit fibers, information about supplements is also available.

3.4 Motivation

A good clinician senses when a patient is struggling, losing motivation, and even losing ground in their attempt to change behavior. When the simple suggestions don't get people over behavioral barriers to change, a more motivational session may be in order.

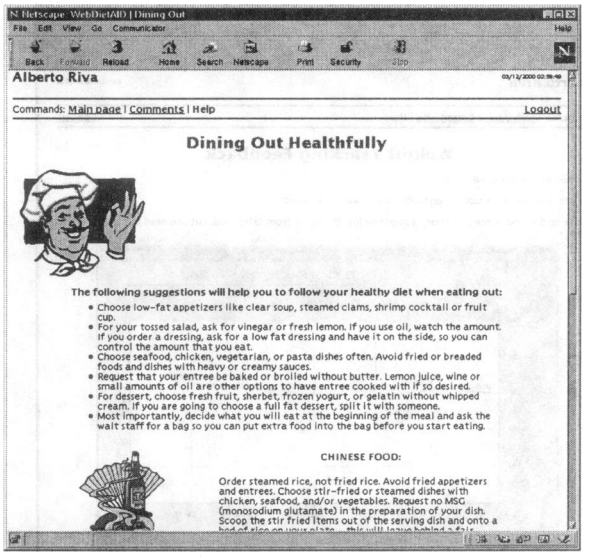

Figure 2: An advisor providing advice on how to eat healthfully in restaurants.

WEBDIETAID uses a formal procedure to deal with motivation. A "readiness to change assessment" helps determine whether the user is ready to change his/her dietary behavior in a direction that will lower cholesterol. WEBDIETAID includes a motivational advisor whose task is to determine a user's current state with respect to behavior change. The advisor can modify the intervention according to user responses, providing information which moves the person to a stage of greater readiness to change. For example, a user who is ready to change could be presented details about how to substitute low fat foods for foods rich in fat or saturated fat, how to reduce portion sizes, or simply to eat certain foods on fewer occasions. On the other hand, such information would not be appropriate for users who are not ready to make these changes in their lifesytle.

Finally, some psychological counseling can be useful as well. Users can enter into a guided discussion of what they are thinking and how they are feeling about food and their dietary behaviors. WEBDIETAID employs interactions based on transactional analysis [8] to this purpose.

4 Conclusions and future work

The nutrition counseling process has many elements, and WEBDIETAID provides users with many opportunities to receive information and counseling on the subjects that pertain to lowering their serum cholesterol. A very important task of the system is, therefore, to guide the users towards the topics that have a higher priority, as an expert clinician would do. To this end, it incorporates rules that take into account the intrinsic value of a topic, the user model, and temporal information such as when was the topic last reviewed, and for how long. We are only beginning to experiment with such rules, and we expect the complexity of the scheduling system to grow as the number of implemented advisors increases.

Another issue we are investigating is the definition of the user model. It is hard to predict what information about a user an advisor might need. The amount of data to store in the database can become quite large. Intelligent abstraction techniques will therefore be needed to generate high-level descriptors of the users from a record of their interactions with the system. This record might include answers to food and exercise questionnaires, the time spent reading certain pages, frequency of access to the system, and motivational state. Although WEBDIETAID is still under development, we are confident that the use of the LISPWEB environment will make it possible to reach these goals and to build a highly effective, flexible and interactive counseling system.

We also plan to apply the same Web-based counseling architecture to other health behavior domains. For example, behavioral intervention in the field of smoking cessation shares several characteristics with the one described in this paper. At the same time, the set of advisors and their activation strategies would certainly be different. The flexible and dynamic architecture of our development environment will allow us to easily implement several different education and counseling systems for behavior change, by defining new advisors and creating new knowledge bases they operate on.

Acknowledgements

We wish to thank Benjamin Bassey for his help in implementing WEBDIETAID.

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